

CLAIMS

What is claimed is:

- 1 1. A magnetic head having an air bearing surface (ABS), comprising:
 - 2 a free layer; and
 - 3 an antiparallel (AP) pinned layer structure spaced apart from the free layer, the
 - 4 AP pinned layer structure including at least two AP-pinned layers having
 - 5 magnetic moments that are self-pinned antiparallel to each other, the AP-
 - 6 pinned layers being separated by an AP coupling layer;
 - 7 wherein an easy axis of a first of the AP-pinned layers is oriented at an angle of at
 - 8 least 5° from the ABS along a plane of the first AP-pinned layer.
- 1 2. A head as recited in claim 1, wherein an easy axis of each of the AP-pinned layers
- 2 is oriented at an angle of at least 5° from the ABS along a plane of the associated
- 3 AP-pinned layer.
- 1 3. A head as recited in claim 1, wherein the easy axis of the first AP-pinned layers is
- 2 oriented at an angle of between about 30° and about 60° from the ABS along a
- 3 plane of the first AP-pinned layer.

- 1 4. A head as recited in claim 1, wherein the easy axis of the first AP-pinned layer is
 - 2 oriented at an angle of between about 40° and about 50° from the ABS along a
 - 3 plane of the first AP-pinned layer.
 - 1 5. A head as recited in claim 1, wherein easy axes of the AP pinned layers are
 - 2 oriented at about the same angle.
 - 1 6. A head as recited in claim 1, wherein easy axes of the AP pinned layers are
 - 2 oriented at different angles.
 - 1 7. A head as recited in claim 1, wherein the easy axis is set by forming the first AP-
 - 2 pinned layer in the presence of an applied magnetic field having flux oriented at
 - 3 an angle of at least 5° from the ABS along the plane of the first AP-pinned layer.
 - 1 8. A head as recited in claim 1, wherein the AP pinned layer structure is self pinned,
 - 2 the AP pinned layer structure not being stabilized by an antiferromagnet.
 - 1 9. A head as recited in claim 1, wherein the magnetizations of the AP-pinned layers
 - 2 are oriented perpendicular to the ABS.
 - 1 10. A head as recited in claim 1, further comprising an AFM layer.

1 11. A head as recited in claim 11, wherein the easy axis of the first AP-pinned layer is
2 oriented at an angle of between about 5° and about 45° from the ABS along a
3 plane of the first AP-pinned layer.

1 12. A head as recited in claim 1, wherein the head is a CPP GMR sensor.

1 13. A head as recited in claim 1, wherein the head is a CPP tunnel valve sensor.

1 14. A head as recited in claim 1, wherein the head is a CIP sensor.

1 15. A magnetic head having an air bearing surface (ABS), comprising:
2 a free layer; and
3 an antiparallel (AP) pinned layer structure spaced apart from the free layer, the
4 AP pinned layer structure including at least two AP-pinned layers having
5 magnetic moments that are self-pinned antiparallel to each other, the AP-
6 pinned layers being separated by an AP coupling layer;
7 wherein the easy axes of the AP-pinned layers are oriented at an angle of between
8 about 30° and about 60° from the ABS along a plane of the associated AP-
9 pinned layer.

1 16. A head as recited in claim 15, wherein the easy axis of each of the AP-pinned
2 layers is oriented at an angle of between about 40° and about 50° from the ABS
3 along a plane of the associated AP-pinned layer.

- 1 17. A head as recited in claim 15, wherein the angle of each of the easy axes is about
- 2 the same.

- 1 18. A head as recited in claim 15, wherein the angles of the easy axes are different.

- 1 19. A head as recited in claim 15, wherein the easy axis is set by forming the AP-pinned layers in the presence of an applied magnetic field having flux oriented at an angle of between about 30° and about 60° from the ABS along the plane of the first AP-pinned layer.

- 1 20. A head as recited in claim 15, wherein the AP pinned layer structure is self pinned, the AP pinned layer structure not being stabilized by an antiferromagnet.

- 1 21. A head as recited in claim 15, wherein the magnetizations of the AP-pinned layers are oriented perpendicular to the ABS.

- 1 22. A head as recited in claim 15, further comprising an AFM layer.

- 1 23. A head as recited in claim 22, wherein the easy axis of the first AP-pinned layer is oriented at an angle of between about 5° and about 45° from the ABS along a plane of the first AP-pinned layer.

- 1 24. A head as recited in claim 15, wherein the head is a CPP GMR sensor.
- 1 25. A head as recited in claim 15, wherein the head is a CPP tunnel valve sensor.
- 1 26. A head as recited in claim 15, wherein the head is a CIP sensor.
- 1 27. A magnetic storage system, comprising:
 - 2 magnetic media;
 - 3 at least one head for reading from and writing to the magnetic media, each head
 - 4 having:
 - 5 a free layer; and
 - 6 an antiparallel (AP) pinned layer structure spaced apart from the free
 - 7 layer, the AP pinned layer structure including at least two AP-
 - 8 pinned layers having magnetic moments that are self-pinned
 - 9 antiparallel to each other, the AP-pinned layers being separated by
 - 10 an AP coupling layer;
 - 11 wherein an easy axis of a first of the AP-pinned layers is oriented at an
 - 12 angle of at least 5° from the ABS along a plane of the first AP-
 - 13 pinned layer;
 - 14 a slider for supporting the head; and
 - 15 a control unit coupled to the head for controlling operation of the head.